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UNITED STATES GYPSUM COMPANY

LIME

IN BUILDING CONSTRUCTION

LIME

LIME

Even before Abraham left Ur of the Chaldees to found a new religion, lime was being used in the construction of vast monuments. Excavations of cities that thrived during the earliest civilizations have produced evidence of the use of lime as a cementing mortar and as a plaster.

The Greeks and Romans adopted the use of lime from older civilizations and further developed its use as an ornamental material, in their buildings. Its use in building construction has been continuous down to the present day.

The chemical properties of lime were discovered and began to be utilized at a later date than its cementing property. Its value for sanitary purposes was known to the ancients and lime has been used for generations in agriculture and many industries. Today, lime is used in the production of textiles, leather, paper, glass, paints and many other articles of everyday use.

This book has been prepared to present the best available information regarding the processes of manufacturing lime; the kinds of lime produced; how lime is used in preparing mortar, plaster, stucco and concrete for building construction; and how it corrects soil conditions and improves crop production in agriculture.

UNITED STATES GYPSUM COMPANY

U S G Lime Plant, Genoa, Ohio.

CONTENTS

LIME

GENERAL DESCRIPTION AND CLASSIFICATION

■ Lime is produced by burning limestone, a very common rock of wide distribution and found in every state in the United States.

Pure limestone is a chemical combination of calcium, carbon and oxygen, and designated as calcium carbonate. Limestone, as it is found in the various deposits, contains magnesium in varying quantities, also small quantities of impurities such as silica, iron and alumina.

KINDS OF LIMESTONE

This variation in chemical composition has resulted in three classifications of limestone (and the limes produced from them) as follows:

1. High Calcium Limestone

Contains at least 93% calcium carbonate (calcium, carbon and oxygen).

2. Magnesian Limestone

Contains from 80% to 93% calcium carbonate, and 7% to 20% of magnesium carbonate (magnesium, carbon and oxygen).

3. Dolomite or High Magnesium Limestone

Contains approximately equal proportions of calcium carbonate (55%) and magnesium carbonate (45%).

Only the limes which are produced from limestones of the first and third class are considered here. There are few deposits of magnesian limestone that are of commercial value. Limestones used in the manufacture of lime for use in building construction either have a high calcium content or a high magnesium content.

THE MANUFACTURE OF LIME

Quarry Location

The location of the quarry to be the source of raw material is a most important undertaking. When done scientifically with diamond point drills, the quality, uniformity and extent of the rock deposit can be quite accurately determined. No lime plant can hope to survive without a good grade of rock readily available, so the rock source is carefully investigated before locating and building a lime plant. Nature has endowed certain parts of the country with purer limestones than it is possible to find in other sections. There are instances where varying amounts of foreign materials are so intimately mixed with the rock that it is impossible even by careful sorting to eliminate objectionable impurities. The United States Gypsum Company has located its plants at points extending from coast to coast where the purest deposits of limestone are to be found.

Selection of the Rock

Man's skill first enters the manufacture of lime in the selection and sorting of rock. Experience, skill, patience and close collaboration with a chemical laboratory are necessary to produce a lime of high quality and uniform physical characteristics. There is no formula for the selection of the stone to make a good lime. Only long experience and careful supervision can achieve high quality. Proper physical characteristics of the rock are equally as important as the chemical composition.

LIME • GENERAL DESCRIPTION AND CLASSIFICATION

Manufacturing Process—Shaft Kilns

The Burning Process

To produce lime, it is necessary for the limestone to be heated to a temperature of 1800° to 2200° F. To achieve this, a number of different types of kilns have been used. As the knowledge of materials and design has increased, kiln design has been improved. The first type of kiln was the "Flare" kiln which was merely a pile of limestone built loosely over a pile of wood. Then as wood became scarce the pot or mixed feed kiln, in which lime was produced by introducing a layer of coal and a layer of limestone was developed. It was a slow and tedious method. The quality of the lime produced was variable, containing not only all of the impurities in the coal, but variable quantities of raw limestone and unburnt coal.

Lime is now produced in two general types of kilns: (1) the shaft or vertical type, and (2) the rotary or horizontal type.

Shaft Kilns

Shaft kilns are a modification of the old mixed feed kiln, their basic difference being that the generation of heat in a combustion chamber or furnace is separate from the part of the kiln holding the limestone. The heat passes through an "eye" or arch into contact with the limestone. Nearly every type of fuel is used in the shaft kiln; – oil, coal, gas and wood. Wood, because it gives a long soft flame, produces a soft-burned highly reactive lime. With the other fuels, combustion is controlled as much as possible to give a flame duplicating the soft burning obtained with wood. When using other fuels than wood, it is customary to "bleed in" low pressure steam under the fire box.

The rock going into the shaft kiln is in lumps from 5 to 12 inches in diameter. The temperature of the rock is gradually increased as it is drawn down through the kiln and when it approaches the "eye" or arch of the kiln, the temperature is sufficient to produce lime. The lime is drawn off at the bottom of the shaft kiln and more rock falls down into the hot zone of the kiln. (See illustration on page 5.)

Because only large lumps are burned in a shaft kiln, the surface area of the rock exposed to the flame is small. Under the proper conditions, and with careful sorting of the lime after drawing, it is possible to produce a very high grade lime in a shaft kiln. Shaft kiln lime will contain lumps that have not been thoroughly decarbonated or burned. These lumps will have a core of unburnt limestone and it is necessary to sort out those containing large cores. If the lime in a shaft kiln is permitted to remain too long in the hot zone of the kiln, it is over-burned and a fusion or "dead-burning" of the lime occurs.

An idealized modern lime plant showing the sequence of operations in the manufacture of lime. Courtesy National Lime Association.

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Rotary Kilns—Kinds of Lime—Quicklime

Rotary Kilns

The rotary kiln was first used in the manufacture of portland cement. The record is not clear, but probably the first lime made in rotary kilns was made at a cement plant. The rotary kiln has several advantages in its favor, in that it is fed mechanically, is continuous in operation, discharges automatically, and operates under closely controlled combustion conditions. Rock size of $\frac{1}{2}$ to $2\frac{1}{2}$ inches is used. Certain types of stone that cannot be used in a shaft kiln can be burned satisfactorily in a rotary. Care must be used to get a uniform clean rock because sorting after burning is impossible. Most rotary kilns are fired with gas or oil, but if purity is not essential, powdered coal can be used. Combustion conditions must be regulated to give a long flame. (See illustration below.)

With careful experienced operation, the lime produced by a rotary kiln generally will run more uniform than the unselected product of a vertical kiln. The relative merits of a rotary and a vertical kiln have been argued at great length. Lime burned in a rotary has far greater surface area exposed to the flame, with the greater possibility of overburning. There is also the possibility of the fines being overburned and greater silicious impurity from the abrasion of the lime on the kiln lining. A rotary burned lime is a very hot, quick slaking material.

Rotary kiln lime is screened after it comes from the kiln. The coarse material is shipped as pebble lime, and the fines are generally converted to hydrate.

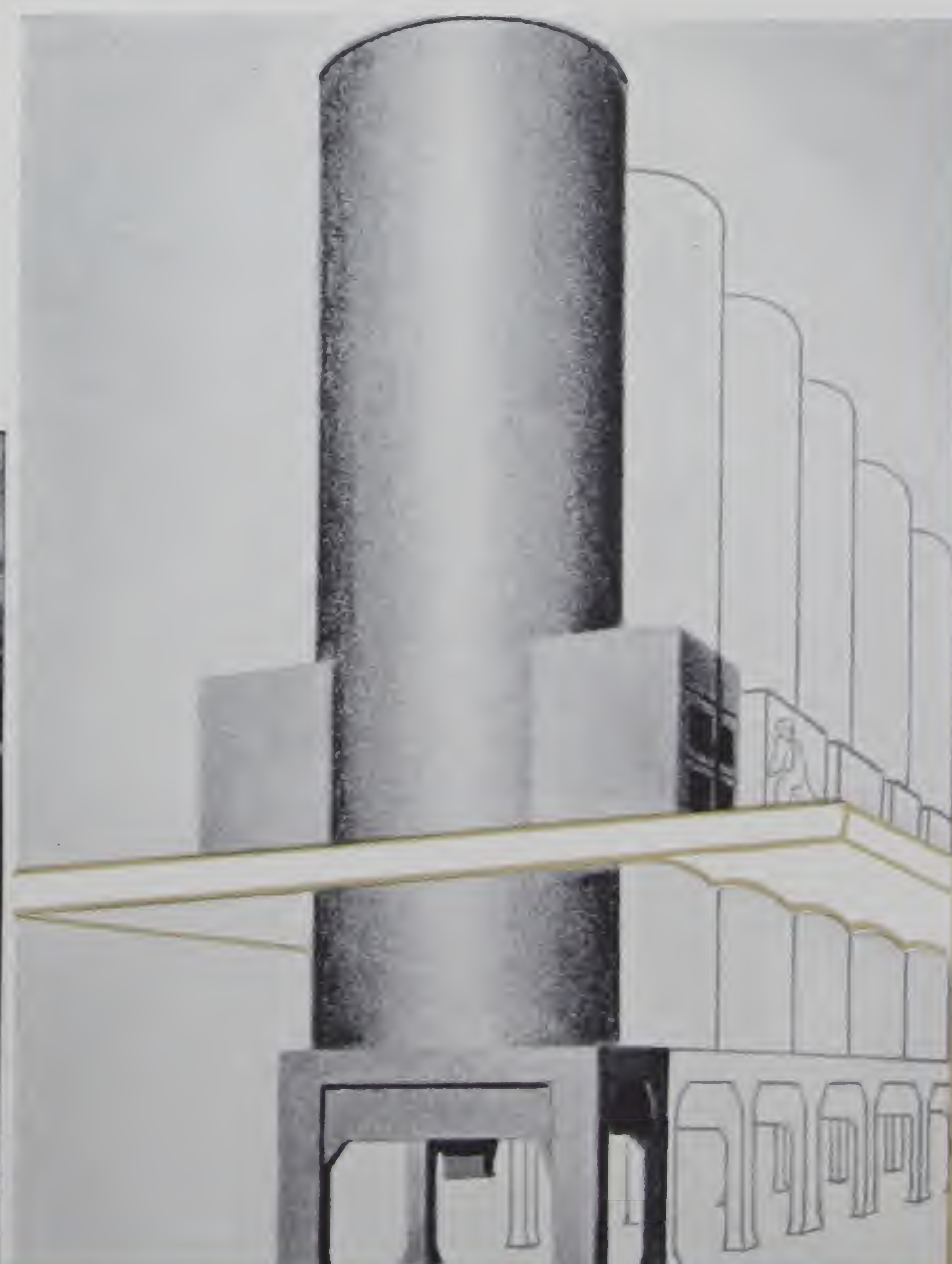
KINDS OF LIME

Quicklime

The application of heat to limestone breaks up the rock and drives off carbon dioxide gas, leaving the product known as quicklime, or in chemical terms, calcium oxide. If dolomite is treated in the same manner, the resulting quicklime is a mixture of calcium oxide and magnesium oxide.

If the limestone used contains a considerable amount of clayey matter, or iron oxide, the quicklime resulting from the burning will not be white, but will vary from yellowish to gray or brown in color, according to the amount and kind of impurities in the raw stone. Generally it will slake much slower than a purer lime.

Rotary Lime Kiln



Shaft Lime Kiln

LIME • GENERAL DESCRIPTION AND CLASSIFICATION

Kinds of Lime—Hydrated Lime

The limestone burned in shaft or stationary kilns is in large pieces from 5 inches to 12 inches in size. The burning process does not alter the size and the resulting product is ordinarily known as lump lime and is sold under that name.

As the lump lime is drawn from the kiln it is carefully inspected and all pieces containing unburned cores are removed.

If a quicklime of smaller size is wanted, the lump lime may be crushed or ground to whatever size the customer desires. Finely divided lime reacts very quickly in any chemical process and is therefore frequently required for industrial use. The finer sizes of limes produced by grinding are easier to handle and can be shipped in small containers. These finer limes are designated as granular lime, fine grain lime, pulverized lime and ground lime.

Another type of quicklime is produced from burning limestone in a rotary kiln. The limestone fed to the rotary kiln is generally of ½ inch to 2 inches in size. The resulting product is known as pebble lime.

Batch Hydrator—This consists of a circular pan which revolves horizontally and holds about 1½ tons of hydrated lime, and a shaft with arms radiating from its lower end. The arms carry plows which scrape the bottom of the pan as it revolves thus mixing the lime and water thoroughly. When the evolution of steam ceases, hydration is complete. Illustration of Clyde Lime Hydrator courtesy of Blaw-Knox Company.

Hydrated Lime

Hydrated lime is ground quicklime which has been slaked or hydrated in special equipment at the manufacturer's plant. Hydrated lime may be manufactured from either high calcium lime or dolomitic lime, produced in either shaft or rotary kilns.

Hydrating consists of adding to the quicklime the correct quantity of water to form calcium hydroxide or hydrated lime. Hydration in the plant is under exact control in either the batch or continuous process of manufacture. The operation is accurately controlled so that just sufficient water is added for complete slaking or hydrating of the quicklime. This results in a fine grained, dry material.

Mechanical hydrators are of two types, (1) the intermittent or batch hydrator (see illustration on this page) and (2) the continuous hydrator (see next page). Since considerable heat is evolved during hydration, care must be taken to prevent any local overheating. If a dry hydrate is being produced, the quantity and method of adding water must be carefully controlled.

The quantity of water required varies with the nature of the lime and with atmospheric conditions. Different types of hydrators work better with certain types of lime. Through the use of temperature recording equipment and experienced operators, a uniform material can be regularly produced. The dry hydrate is usually permitted to "age" for a short period of time in a bin to stabilize. Laboratory tests showing the combined water content of the hydrate are a positive means of control. If the hydration has been done properly, the hydrate will be in a finely divided form.

After hydrating, the lime is ground and air separated to the required fineness. This assures a product free from any oversize material and of uniform composition and physical characteristics. In general, hydration improves the color and the resulting hydrate is a white powder of excellent keeping quality and uniform working qualities.

Hydrated lime is packed and shipped in standard multi-wall paper bags, see page 27. When necessary, due to special conditions, hydrated lime may be shipped in drums or barrels, or in bulk direct from the manufacturing plant.

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Flow Chart of Lime Manufacture

Hydrated lime as compared to quicklime is a stable material and under good storage conditions, in paper bags, shows very little deterioration over several months time. There is always the added advantage that there is no fire hazard in stored hydrated lime. For many industrial uses, stability of composition and fineness offsets the higher cost of hydrated lime.

FLOW CHART OF LIME MANUFACTURE AND TYPES OF LIME

High Calcium Limestone $CaCO_3$ — Dolomitic Limestone $CaCO_3MgCO_3$

Coal, Gas, Wood } Fuel—Heat — **Shaft Kiln or Rotary Kiln** — Carbon Dioxide (CO_2)

Quicklime

GRADES AND TYPES		High Calcium or Dolomitic
Lump	4″ to 10″	in bulk or barrels or bags
Crushed Lump	2″ to Dust	" " " " " "
Pebble	1″ to 2″	" " " " " "
Pulverized 20 to 50 per cent through 100 screen		" " " " " "
Finely Ground 50 to 98 per cent through 100 screen		" " " " " "

Water

Hydrator

Hydrated Lime

Air Separator

Chemical / Masons and Finishing / Spray or Superfine

Packer

Automatic pulverizer with air separation used in lime manufacture. Courtesy Raymond Bros. Impact Pulverizer Company.

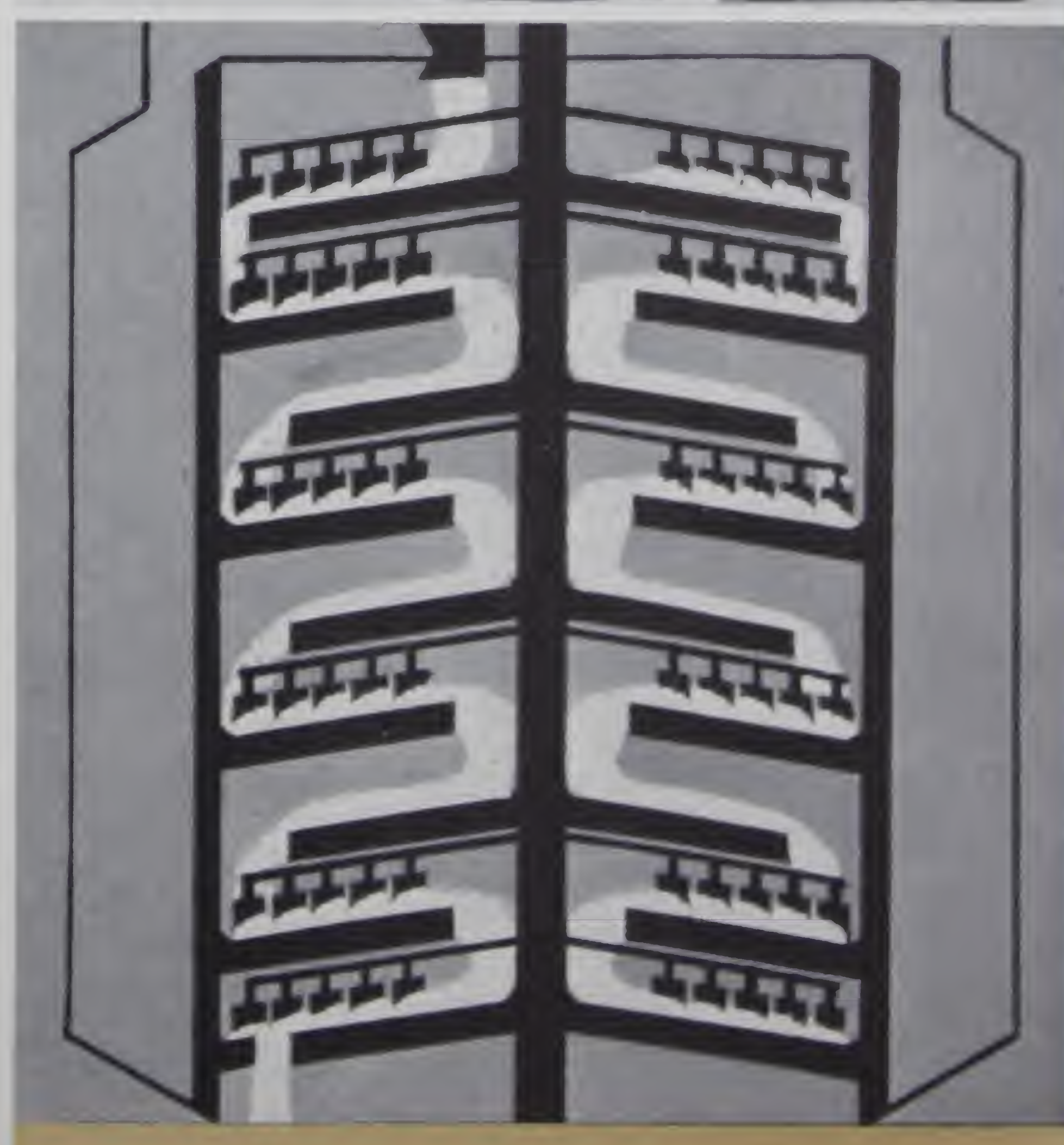


Diagram of continuous lime hydrator. The Lime enters through a poidometer feed at the top. Water is added in an accurate proportion. The revolving plows thoroughly mix the lime and water and carry the mix to the bottom where it emerges as dry hydrated lime.

LIME • GENERAL DESCRIPTION AND CLASSIFICATION

Properties of Lime—High Calcium and Dolomitic Lime

PROPERTIES OF LIME

Quicklime

Quicklime has a great affinity for water and carbon dioxide. If left exposed for any considerable length of time it will absorb water and carbon dioxide from the air. This produces a gradual hydration and carbonation and, in time, the lime will lose its chemical activity and revert to its original form of calcium carbonate.

This is known as air-slaking, and to guard against it, quicklime is frequently shipped in air-tight steel drums or other packages that will protect it from contact with air until used. If bulk or loose quicklime is not used promptly after manufacture, air-slaking will change the composition of the lime so that the last of the shipment will differ very substantially from the first part.

Because of the heat produced by slaking of quicklime, care must be used to store it in an absolutely dry place. Contact of quicklime with water may generate enough heat to set fire to any combustible material with which it comes in contact.

Quicklime is highly caustic when brought in contact with water or moisture and special precautions must be taken by workmen who are handling it to prevent serious burns.

When used in building construction, quicklime must be reduced to a lime putty by slaking with water as outlined on pages 18 and 19.

Hydrated Lime

Hydrated lime does not lose its chemical activity from air-slaking as does quicklime; consequently, it keeps well in storage. It can be handled easily and safely, and produces a smooth putty when soaked or mixed with water. For use in building operations hydrated lime is used interchangeably with quicklime.

Hydrated lime is a uniform product, and because it does not air-slake it reaches the user exactly as it left the mill. Because of this quality the last part of the shipment of a stock of hydrated lime will be found to have the same composition as the first part, if used within a reasonable time.

Comparison of High Calcium and Dolomitic Lime

Quicklime or hydrated lime as, has been previously stated, can be produced from either high calcium limestone or dolomite. In building construction, either type of lime may be used. On the other hand, in many industrial processes the chemical composition is of major importance.

High calcium quicklimes, because of their high calcium oxide content, slake rapidly when water is added and evolve much heat during the slaking. They also expand greatly, giving a large bulk of slaked lime or lime putty.

Dolomitic quicklimes slake slower. Their expansion is less and the resulting bulk of slaked lime is less. These qualities are due to the composition of dolomitic lime which contains practically 41% magnesium oxide and 57% calcium oxide.

High calcium quicklime, as a general rule, produces from one-third to one-fourth more putty by volume than dolomitic lime. This excess volume is water and does not indicate that a putty made from high calcium quicklime contains more cementing material, as both calcium oxide and magnesium oxide act as cementing agents in a sand mix. In fact, considering equal volumes of high calcium putty and dolomitic putty, the latter contains more cementing material and will produce a stronger mortar.

LIME IN BUILDING CONSTRUCTION

■ The use of lime as a cementing material in masonry structures can be traced back to the earliest historical times.

The art of plastering was developed to a high state of perfection by the ancients. The Greeks used lime extensively as did the Romans. During the Middle Ages practically all masonry was laid with lime mortar and lime was used for all interior plastering.

The important uses of lime in modern building construction are: For masonry mortars; for finishing plasters; for base coat plasters; for stucco finishes; for admixture in concrete, and for cold water paints and whitewash.

LIME IN MASONRY MORTAR

Water-tightness and durability are the real criteria of quality in masonry regardless of the type of building units used. If the units are thoroughly burned brick or tile, hard dense stone or concrete, and the construction correct, any excessive penetration of water into a masonry wall can occur only at the mortar joints. To prevent this the mortar must be adaptable; that is, one that can be easily worked; one that will adhere satisfactorily to the building unit used, and one that does not have excessive volume changes after hardening. The durability of masonry is, to a large extent, dependent upon the durability of the mortar joints. Practically all of the materials used as building units are sufficiently durable to insure a permanent wall.

Essentials for an Adaptable Mortar

PLASTICITY Plasticity, or workability, in a mortar is an important factor in producing economical, water-tight masonry. The building units must be thoroughly and uniformly bedded and the joints well filled to assure leakless masonry. Most masons use the "shove" method of placing bricks, and if the mortar is lacking in plasticity a uniform distribution of mortar is impossible.

Lime is the most plastic of all cementing materials used in masonry because of its ability to retain water which is the lubricating medium in all mortars. It makes an easy-working mortar with any given sand, and is one of the best assurances of good workmanship. Where bricks with core holes are used, this plasticity enables the mortar to work into the core holes without extra labor on the part of the workmen.

ADHESION Adhesion, or bonding power, is an important quality in masonry mortar. Unless the mortar adheres to the building unit uniformly and completely at all points of contact between the unit and the mortar, and has sufficient elasticity to adjust itself to varying stresses, it will tear loose from the building unit and weaken the wall.

Perfect mortar adhesion is also necessary to prevent excessive water penetration at the joints. Adhesion, to a certain extent, depends on the plasticity of the mortar.

A mortar of high plasticity is more easily worked to fill the joints thoroughly and bed the building units uniformly.

It is evident that the adhesive strength of the mortar must be sufficient under all conditions and with various types of building units to equal or exceed the tensile strength of the mortar.

LIME • IN BUILDING CONSTRUCTION

Volume Changes—Table of Bond Strength

The history of laboratory tests and observations on actual construction indicates that mortars containing a high lime content have great adhesive strength. Table 1 contains data obtained from tests by the National Bureau of Standards. The tensile strength of these specimens was not actually measured in these tests, but the tensile strength of mortar is approximately proportional to the corresponding compressive and transverse strengths shown in the table.

VOLUME CHANGES Compacting of mortar occurs only when a mortar low in water retaining capacity comes into contact with a porous wall unit. It takes place immediately after the instant of contact and results in rapid stiffening of the mortar, loss of workability and loss of water.

Compacting prevents uniform contact between the mortar bed and the next course of building units. It prevents the slushing of sufficient mortar into the joints to fill them properly. It prevents the mortar in the bed from flowing down and filling any vertical joints left open by the mason.

One of the important causes of leakage in masonry is the compacting of the mortar in vertical

TABLE 1

Bonding Power of Mortars as Indicated by the Ratio of Strength of Bond to Compressive and Transverse Strength of Mortars at 3 Months Aging Period

Mortar Composition Lime: Cement: Sand (By Volume)	Compressive strength of mortar at 3 mos.	Transverse strength of mortar at 3 mos.	Brick	Suction of brick when laid. Grams of water absorbed through flat surface in one minute	Ratio, bond strength at 3 mos. to compressive strength of mortar at 3 mos.	Ratio, bond strength at 3 mos. to transverse strength of mortar at 3 mos.
	lbs./in.²	lbs./in.²		grams		
0:1:3	1,435	472	No. 1 set dry	117	0.008	0.024
0:1:3	1,435	472	No. 1 set wet	3	0.049	0.149
0:1:3	1,435	472	No. 3 set dry	10½	0.050	0.153
0:1:3	1,435	472	No. 6 set dry	72	0.020	0.061
1:1:6 (Lime No. 1)	447	149	No. 1 set dry	117	0.052	0.156
1:1:6 (Lime No. 1)	447	149	No. 1 set wet	3	0.080	0.240
1:1:6 (Lime No. 1)	447	149	No. 3 set dry	10½	0.094	0.280
1:1:6 (Lime No. 1)	447	149	No. 6 set dry	72	0.077	0.230
1:1:6 (Lime No. 2)	686	166	No. 1 set dry	117	0.038	0.160
1:1:6 (Lime No. 2)	686	166	No. 1 set wet	3	0.059	0.244
1:1:6 (Lime No. 2)	686	166	No. 3 set dry	10½	0.076	0.314
1:1:6 (Lime No. 2)	686	166	No. 6 set dry	72	0.052	0.210
2:1:9 (Lime No. 2)	357	118	No. 1 set dry	117	0.072	0.217
2:1:9 (Lime No. 2)	357	118	No. 1 set wet	3	0.063	0.192
2:1:9 (Lime No. 2)	357	118	No. 3 set dry	10½	0.092	0.280
2:1:9 (Lime No. 2)	357	118	No. 6 set dry	72	0.078	0.236
3:1:12 (Lime No. 1)	168	109	No. 1 set dry	117	0.102	0.157
3:1:12 (Lime No. 1)	168	109	No. 1 set wet	3	0.077	0.120
3:1:12 (Lime No. 1)	168	109	No. 3 set dry	10½	0.175	0.270
3:1:12 (Lime No. 1)	168	109	No. 6 set dry	72	0.126	0.200
1 portland cement; 3 sand plus 15 per cent of hydrated lime by volume of cement	2,185	646	No. 1 set dry	117	0.0001	0.0003
1 portland cement; 3 sand plus 15 per cent of hydrated lime by volume of cement	2,185	646	No. 1 set wet	3	0.023	0.077
1 portland cement; 3 sand plus 15 per cent of hydrated lime by volume of cement	2,185	646	No. 3 set dry	10½	0.035	0.119
1 portland cement; 3 sand plus 15 per cent of hydrated lime by volume of cement	2,185	646	No. 6 set dry	72	0.007	0.025

Note: The same typical gray portland cement, meeting A.S.T.M. Standard Specifications, was used throughout.

From "Masonry Mortar, Bulletin 321" published by National Lime Association.

Extensibility and Factors of Safety for Mortars

joints leaving openings that allow penetration of moisture.

Lime mortar has a high water retaining capacity and even when used with porous building units, will undergo a minimum of compacting.

Expansion and contraction of some mortars after hardening occur to a certain extent from changes in temperature, but are greatest from alternate wetting and drying. Such volume changes may be responsible for the development of cracks due to breaking of the mortar bond if the mortar does not possess sufficient strength.

Lime is the only cementitious material having a negligible volume change after it has hardened. Therefore, the greater the lime content in any given mortar the less possibility there is for excessive volume changes in the mortar.

EXTENSIBILITY Extensibility is the quality that determines the extent to which a mortar will stretch before it will fail in tension. The real value of this quality is in its relation to the volume changes after the mortar hardens. If the extent of shrinkage is greater than the extensibility of the mortar, the result will be cracked mortar joints or broken bond

TABLE 2
Extensibilities and "Factors of Safety" of Mortars, Age 3 months — Average of 3 tests

Mortar Composition Lime: Cement: Sand By Volume	Extensibility, inches per 100 inches	Maximum shrinkage subsequent to hardening inches per 100 inches	Factor of safety, values of second column divided by the corresponding values of the third column
0:1:3 (portland cement No. 1) (a)	0.026	0.084	0.31
0:1:3 (portland cement No. 2) (b)	0.025	0.071	0.35
0:15:1:3 (portland cement No. 1 and lime No. 3)	0.031	0.076	0.41
1:1:6 (portland cement No. 1 and lime No. 1)	0.028	0.038	0.74
2:1:9 (portland cement No. 1 and lime No. 1)	0.030	0.026	1.16
3:1:12 (portland cement No. 1 and lime No. 1)	0.025	0.010	2.50
1:0:3 (lime No. 1) (c)	0.031	0.007	4.43
1:0:3 (lime No. 2) (d)	0.028	0.004	7.00
1:0:3 (lime No. 3) (e)	0.022	0.001	22.00
1:0:3 (lime No. 4) (f)	0.025	0.006	4.20
1:1:6 (portland cement No. 2 and lime No. 1)	0.023	0.049	0.47
2:1:9 (portland cement No. 2 and lime No. 1)	0.024	0.027	0.90
3:1:12 (portland cement No. 2 and lime No. 1)	0.024	0.017	1.41
1:1:6 (portland cement No. 1 and lime No. 3)	0.022	0.037	0.60
2:1:9 (portland cement No. 1 and lime No. 3)	0.025	0.019	1.31
3:1:12 (portland cement No. 1 and lime No. 3)	0.024	0.013	1.85

(a) Portland Cement No 1—Typical Grey Portland Cement meeting A.S.T.M. Standard Specifications.

(b) Portland Cement No. 2—White Portland Cement meeting A.S.T.M. Standard Specifications.

(c) Lime No. 1—Quicklime meeting A.S.T.M. Standard Specifications.

(d) Lime No. 2—Hydrated Lime meeting A.S.T.M. Standard Specifications.

(e) Lime No. 3—Hydrated Lime meeting A.S.T.M. Standard Specifications.

(f) Lime No. 4—Quicklime meeting A.S.T.M. Standard Specifications.

From "Masonry Mortar, Bulletin 321"
Published by the National Lime Association.

between the mortar and building units. Lime mortars or lime and Portland cement mortars containing a preponderance of lime have an extensibility sufficient to provide a factor of safety of one or more which is a desirable condition. (See table 2.)

STRENGTH Practical construction experience has proved that excessive compressive and tensile mortar strength is not necessary to obtain strong masonry, as even the weakest mortars normally used in construction work produce a masonry of sufficient strength and with a reasonable factor of safety.

Strength in mortar does not necessarily indicate durability. The choice of the mortar mix solely on the basis of strength often involves a sacrifice of other important qualities, such as plasticity, adhesion and minimum volume changes after hardening.

It has been shown in previous paragraphs that these qualities are obtained through the use of lime in the mortar. Available test data indicate that the use of lime in masonry mortar produces a mortar of ample strength. Many examples of the enduring qualities of masonry laid in lime are to be found in the older structures of Europe and America.

MORTAR MIXES

From the foregoing paragraphs it is apparent that lime provides the essential qualities of water retaining capacity, plasticity, workability, adaptability, adhesion and low volume changes after hardening.

The following mortar recommendations are quoted from Masonry Mortar, Bulletin 321, published by the National Lime Association:

TABLE 3

Mortar Mixes for Various Types of Masonry

Masonry Type	Type of Construction	Loading	Mortar Proportions (Volume) Lime: Cement: Sand	Remarks
Common and face clay, shale or sand-lime brick.	Dwellings, garages and similar construction.	Any condition of loading for such types of construction.	1:0:3 1:0:3 1:0:3	
Clay or shale brick.	Walls and piers below grade continuously exposed to wet or damp conditions.	Ordinary distributed Heavy concentrated Earthquake tremors.	1:1:6* 1:1:6* 1:1:6*	
Common and face clay, shale or sand-lime brick.	Exterior walls and piers above grade.	Ordinary distributed Heavy concentrated Earthquake tremors.	2:1:9* 2:1:9* 2:1:9*	2:1:5 Mortar for domestic and power plant chimneys.
Granite, limestone, marble, sandstone, terra cotta facing and trim.	Exterior walls and piers above grade.	Ordinary distributed Heavy concentrated Earthquake tremors.	2:1:9* 2:1:9* 2:1:9*	Use non-staining portland cement and washed sand.
Common and face clay, shale or sand-lime brick, concrete brick.	Interior walls and piers above and below grade.	Ordinary distributed Heavy concentrated Earthquake tremors.	2:1:9* 2:1:9* 2:1:9*	
Hollow clay tile, concrete block, concrete tile, cinder block.	Exterior walls above grade and interior partition walls.	Non-bearing partitions, exterior and bearing walls and partitions.	2:1:9* 2:1:9* 2:1:9*	

Notes: Materials to conform to current "A.S.T.M. Standard Specifications."
Mortar containing portland cement to be used within one hour after mixing.

* One volume of cement is the maximum quantity which should be used. The sand content is to be varied in accordance with its quality in the particular market involved and its proportion may be reduced if greater mortar strength is desired.

From "Masonry Mortar, Bulletin 321"
Published by the National Lime Association

LIME • IN BUILDING CONSTRUCTION

Volume of Mortar Required for Brick Walls

"However, in order to avoid delay, where rapid methods of modern construction are employed, the addition of portland cement to lime mortar is recommended, even though this practice adds to the cost of construction and often results in considerable sacrifice in quality of the finished masonry. When cement is so added it replaces an equivalent volume of lime in the mortar mixture.

"It must be remembered that as portland cement is substituted more and more for lime, there is greater and greater sacrifice of the essential properties, water retaining capacity, workability, adaptability, bonding power, and low volume changes subsequent to hardening.

"Laboratory and service tests have both shown that a mortar consisting of two volumes of lime, one volume of portland cement and nine volumes of sand is well adapted for use with a wide variety of units and under a wide variety of conditions, it is therefore recommended for general use where a mortar having a rapid rate of hardening is required. If it is desired that the mortar strength be increased, it is recommended that the sand content be reduced to 7 or 8 volumes but that the ratio, 2 volumes of lime to 1 volume of portland cement, be maintained. This procedure will increase mortar strength with no sacrifice of the more essential properties."

Table No. 3 gives various mortar mixes that have proved successful under various conditions of loading in different types of constructions. Table No. 4 gives volume of mortar required per sq. ft. of wall of various thicknesses. Table No. 5 gives quantities of material required in various mortar mixes.

TABLE 4

Solid Walls in All Bonds

½-INCH JOINTS — ALL JOINTS FILLED WITH MORTAR

SQ. FT. AREA OF WALL	4-INCH WALL		8-INCH WALL		12-INCH WALL		16-INCH WALL		SQ. FT. AREA OF WALL
	No. of Bricks	Cu. Ft. of Mortar	No. of Bricks	Cu. Ft. of Mortar	No. of Bricks	Cu. Ft. of Mortar	No. of Bricks	Cu. Ft. of Mortar	
1	6.160	.075	12.320	.195	18.481	.314	24.641	.433	1
10	62	1	124	2	185	3½	247	4½	10
20	124	2	247	4	370	6½	493	9	20
30	185	2½	370	6	555	9½	740	13	30
40	247	3½	493	8	740	13	986	17½	40
50	309	4	617	10	925	16	1,233	22	50
60	370	5	740	12	1,109	19	1,479	26	60
70	432	5½	863	14	1,294	22	1,725	31	70
80	493	6½	985	16	1,479	25	1,972	35	80
90	555	7	1,109	18	1,664	28	2,218	39	90
100	617	8	1,233	20	1,849	32	2,465	44	100
200	1,233	15	2,465	39	3,697	63	4,929	87	200
300	1,849	23	3,697	59	5,545	94	7,393	130	300
400	2,465	30	4,929	78	7,393	126	9,857	173	400
500	3,081	38	6,161	98	9,241	157	12,321	217	500
600	3,697	46	7,393	117	11,089	189	14,786	260	600
700	4,313	53	8,625	137	12,937	220	17,250	303	700
800	4,929	61	9,857	156	14,786	251	19,714	347	800
900	5,545	68	11,089	175	16,634	283	22,178	390	900
1,000	6,161	76	12,321	195	18,482	314	24,642	433	1,000

From "Brick Structures" published by the Common Brick Manufacturers Association of America.

Quantities of Lime for Masonry Mortar

TABLE 5

Quantity of Materials Required for Masonry Mortar

Lump Quicklime at 70 Cu. Ft. Lime Putty per Ton

PROPORTIONS BY VOLUME			QUANTITY OF MATERIALS REQUIRED — For one cubic yard of mortar			To lay 1000 brick (17 cu. ft.)		
Lime Putty	Cement	Sand	Lime Pounds	Cement Bags	Sand Cu. Yd.	Lime Pounds	Cement Bags	Sand Cu. Yd.
1	0	3	257	0	1	162	0	.63
3	1	12	193	2¼	1	121½	1.42	.63
2	1	9	171½	3	1	108	1.89	.63
1½	1	7½	154	3.6	1	97	2.27	.63
1	1	6	128½	4½	1	81	2.83	.63
½	1	4½	86	6	1	54	3.78	.63
0	1	3	0	9	1	0	5.67	.63
*10%	1	3	26	9	1	16	5.67	.63
*15%	1	3	39	9	1	24	5.67	.63

*Based on Volume of Cement Required.
No allowance for waste.

Courtesy National Lime Association

Pulverized Quicklime at 80 Cu. Ft. Lime Putty per Ton

PROPORTIONS BY VOLUME			QUANTITY OF MATERIALS REQUIRED — For one cubic yard of mortar			To lay 1000 brick (17 cu. ft.)		
Lime Putty	Cement	Sand	Lime Pounds	Cement Bags	Sand Cu. Yd.	Lime Pounds	Cement Bags	Sand Cu. Yd.
1	0	3	225	0	1	142	0	.63
3	1	12	169	2¼	1	106	1.42	.63
2	1	9	150	3	1	94½	1.89	.63
1½	1	7½	135	3.6	1	85	2.27	.63
1	1	6	112½	4½	1	71	2.83	.63
½	1	4½	75	6	1	47	3.78	.63
0	1	3	0	9	1	0	5.67	.63
*10%	1	3	22½	9	1	14	5.67	.63
*15%	1	3	34	9	1	21	5.67	.63

*Based on Volume of Cement Required.
No allowance for waste.

Courtesy National Lime Association

Hydrated Lime at 46 Cu. Ft. Lime Putty per Ton

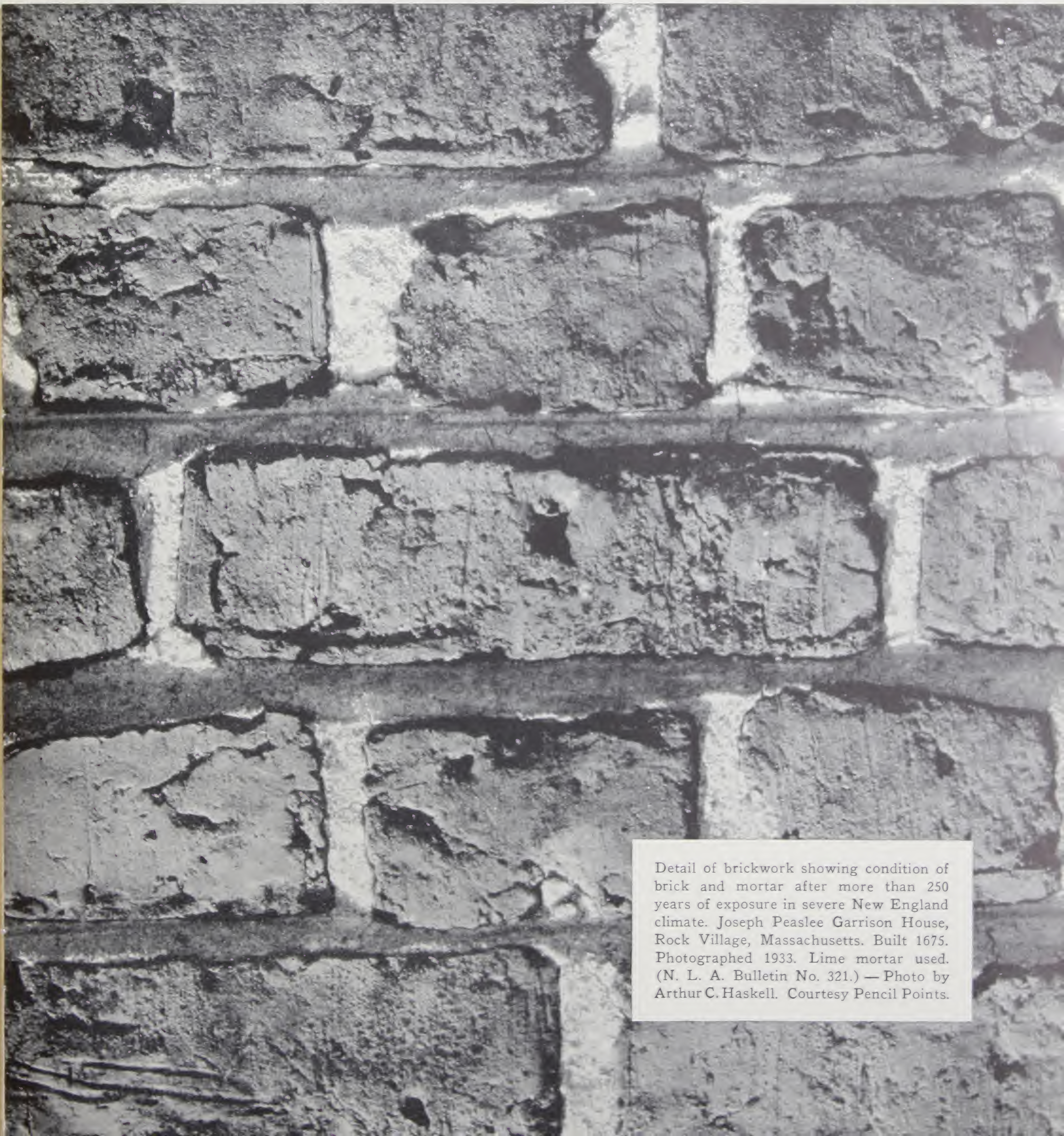
PROPORTIONS BY VOLUME			QUANTITY OF MATERIALS REQUIRED — For one cubic yard of mortar			To lay 1000 brick (17 cu. ft.)		
Lime Putty	Cement	Sand	Lime Pounds	Cement Bags	Sand Cu. Yd.	Lime Pounds	Cement Bags	Sand Cu. Yd.
1	0	3	391	0	1	246	0	.63
3	1	12	239½	2¼	1	185	1.42	.63
2	1	9	261	3	1	164	1.89	.63
1½	1	7½	235	3.6	1	148	2.27	.63
1	1	6	195½	4½	1	123	2.83	.63
½	1	4½	130½	6	1	82	3.78	.63
0	1	3	0	9	1	0	5.67	.63
*10%	1	3	39	9	1	25	5.67	.63
*15%	1	3	59	9	1	37	5.67	.63

*Based on Volume of Cement Required.
No allowance for waste.

Courtesy National Lime Association

LIME • IN BUILDING CONSTRUCTION

Detail of Brick and Mortar After More Than 250 Years Exposure



Detail of brickwork showing condition of brick and mortar after more than 250 years of exposure in severe New England climate. Joseph Peaslee Garrison House, Rock Village, Massachusetts. Built 1675. Photographed 1933. Lime mortar used. (N. L. A. Bulletin No. 321.) — Photo by Arthur C. Haskell. Courtesy Pencil Points.

USG LIME PLANT

The United States Gypsum Company has located its manufacturing plants where lim
deposits of exceptional purity are available. These deposits include both high calciu
dolomitic limestones from which the various brands of U S G lime are produced. These
contain modern equipment for lime manufacturing and are operated under rigid laborator
trol of burning, grinding and hydrating operations. These plants are located at the points
on the map to facilitate prompt service to every section of the United States.

3. NEW BRAUNFELS, TEXAS (left). Produces high calcium hydrated and quicklime.

4. OAKFIELD, (below). Produc hydrated and quick

5. CORDOVA, ILLINOIS (left). Produces dolomitic hydrated and quicklime.

6. EVANS, WASHINGTON (left). Produces high calcium hydrated and quicklime.

TS

limestone
cium and
se plants
tory con-
ts shown

AS
m

D. NEW YORK
duces a dolomitic
uicklime.

1. FARNAMS, MASSACHUSETTS (above). Both quicklime and hydrated lime are produced at this plant. The product is a high calcium lime.

2. GENOA, OHIO (below). The deposit at this point is an exceptionally pure dolomitic limestone. The Genoa plant produces both hydrated lime and quicklime.

Preparing Quicklime for Masonry Mortar

PREPARING QUICKLIME FOR MASONRY MORTAR

Quicklimes must be slaked in water to a putty before they can be used to make mortar. Both high calcium and dolomitic quicklime form the best putty when the slaking mass is allowed to reach the boiling point, and, in fact actually boils during the process. This boiling is necessary for thorough hydration and to bring out the full plasticity and cementing strength of the lime. As high calcium and dolomitic quicklimes react differently in slaking it is necessary to follow a certain definite procedure with each type of lime.

When slaking either high calcium or dolomitic lime in the lump form, the slaked putty should be run through an 8 mesh or finer screen to remove any coarse grit or over-burned lime. When the ground or pulverized types of quicklime are used, screening is not necessary after slaking because any impurities have been reduced to so small a size that they are not harmful in the mix.

After slaking, quicklimes must be aged for at least a week before using. A longer aging is preferable if time permits.

Slaking of High Calcium Quicklime

High calcium, masons, or finishing quicklimes, combine with water almost instantaneously, and give off their heat just as rapidly. For this reason, these limes, whether in ground or lump form must be slaked as follows:

For every 100 lbs. of lime to be slaked, see that at least 200 lbs., or 25 gallons of water, are in the slaking box before the lime is added. Also, have available for dumping into the box another 100 lbs. of water, or another 12 gallons.

Have one man to do nothing but hoe the mix, and another, to add the water and the lime. Dump the lime into the water, spreading it evenly with a hoe. As soon as boiling starts, add water continuously, while hoeing continuously, to keep the mass thick and creamy, but without killing the boiling action.

After the boiling has ceased, stop the addition of water, and run the thick cream through a sieve, if lump lime has been used, permitting the screened lime to set until cool and stiff before sanding.

In case the needs of the work demand it, the screened putty may be sanded at once, although in this case only approximately 50% of the plasticity in the lime may be developed. In cold weather sometimes this sacrifice in plasticity or sand capacity is made in order to get mortar which will not freeze on the job in handling. Remember that boiling of putty during slaking is absolutely necessary.

As a general rule, high calcium lime will take from 30 to 40 gallons of water per hundred pounds of lime in slaking. Care must always be used not to add too much water, as this will lengthen the time required in aging the putty, especially in winter when evaporation is slow.

Slaking of Dolomitic Quicklime

Dolomitic quicklime requires 20 to 30 gallons of water, that is, from 150 to 250 lbs. per hundred pounds of quicklime. In slaking in summer, or when the slaking water is relatively warm, add 15 gallons of water to the slaking box for each 100 lbs. of lime to be slaked.

Scatter the lumps, or sift the ground lime into the water evenly, and do not disturb with the hoe. When boiling starts, as evidenced by crackling in the lime, or by the appearance of dry spots, add water slowly just barely to keep the lime covered, without stopping the boiling action. This may be done by running water slowly from a hose during the slaking process.

At no time during the slaking of dolomitic lime is it necessary to use the hoe in the lime, and it is advisable not to stir the mix, except to level out any dry, hot areas which do not get water.

When boiling and crackling have completely stopped, hoe the entire mass thoroughly, and run through a screen if it is made from lump lime, then permit it to age. If made from ground or pulverized quicklime, screening is not necessary.

In extremely cold weather, or when the lime and the slaking water are both cold, it is permissible, and quite frequently necessary, to put the lime in the slaking box, then add water in one corner to dampen a portion of the lime without covering it with water. This portion is permitted to lie without further wetting until it has begun to heat. If more water is added, the temperature is reduced to the point where the lime will not slake properly and the putty resulting will be a grainy, nonplastic mass.

What To Do and Not To Do in Slaking Lime

WHAT TO DO AND NOT TO DO IN SLAKING LIME

With High Calcium Limes

DO THIS

Place 25 gallons of water in slaking box for every 100 pounds of Lime.

Have available 12 gallons to add later.

Have one man to hoe mix continuously.

Have one man to add water and lime.

Add water continuously and hoe continuously as soon as boiling starts.

DON'T DO THIS

Do not kill boiling action by adding water too rapidly.

Do not add too much water.

With Dolomitic Lime

DO THIS

Place only 15 gallons of water in slaking box for each 100 pounds of lime.

Distribute lime evenly into the water.

When boiling starts add water slowly through hose.

Level out any hot, dry areas.

Keep lime barely covered with water.

Hoe thoroughly when boiling stops.

DON'T DO THIS

Do not hoe lime during slaking except to level out dry spots.

Do not stop boiling action by adding water too rapidly.

Do not drown the lime.

Do not use too much water to start slaking.

General

After slaking is completed run lime through an 8 mesh or finer screen and allow putty to age. Boiling of putty is absolutely necessary during the slaking process.

The use of too much water to start the slaking of a dolomitic lime, or the addition of all the water which is required for the final slaking at the start-off, must absolutely be avoided if "drowning" is to be prevented. The same condition will apply to high calcium lime in extremely cold winter weather, but not to such a great extent.

Remember that boiling of putty during slaking is absolutely necessary. However, dolomitic quicklime that has been in storage for a long time may not boil but will produce a satisfactory lime putty.

PREPARING HYDRATED LIME FOR MORTAR

Hydrated lime is scientifically slaked by the manufacturer and requires only soaking to form a putty for masonry mortar or for finishing plaster.

Three methods of preparing hydrated lime are in use. For every 50 lbs. of hydrated lime place six and one-half gallons of water in the box in which it is to be soaked. Sift the hydrated lime into the water distributing it evenly. The water must cover the lime. The mixture is then allowed to stand without hoeing for at least six hours or over night to develop fully the plasticity of the lime. The putty must be protected from frost or drying out until it is used.

A second method used by many masons and plasterers is said to produce a smoother and more plastic putty. After the hydrated lime has been sifted into the water it is thoroughly hoed, then run through an 8 mesh screen into an aging box and allowed to stand for no less than six hours or over night before using.

The third method is used only with a quick-soaking hydrated lime which is produced in Texas and has a chemical composition that develops its plasticity immediately on being mixed with water. Immediately after sufficient lime has been added to the water to produce a putty of proper consistency, the mixture is given a vigorous hoeing and it is then ready for immediate use. If the putty made of quick-soaking hydrate stands for several hours or over night it should be thoroughly reworked before being used.

LIME • IN BUILDING CONSTRUCTION

Mortar Colors—Lime for Plaster Base Coats

SANDING PRACTICE

When sand is added to lime putty on the weight basis, dolomitic lime and high calcium lime are sanded exactly the same. It is possible to oversand lime mortar, so sanding should be held to the limits of one part of quicklime to between eight and ten parts of sand by weight for ordinary mason's work. Some masons prefer even a richer mix than this. It will be found that regardless of the bulk of the quicklime, for good dolomitic and good high calcium lime, the volume of mortar obtained depends on the amount of sand added per *unit weight of quicklime,* and not per unit volume of putty. The simple facts in the case are that good quicklime of either variety delivers practically the same results in mortar volume when properly mixed.

MORTAR COLORS

Where colored joints are required in the masonry walls the color must be mixed with the mortar. If the desired color can be obtained by the use of colored sand the results will be preferable to those obtained from artificial colors. White joints may be obtained by using a white sand with white lime. If the mortar mix contains cement a white Portland cement should be used.

If artificial mortar colors are used they should be mineral colors and be lime-proof. The brand of colors selected should be manufactured by a responsible concern and the manufacturers' directions for proportioning and mixing followed very strictly.

Mixing Lime Mortar for Masonry.

LIME FOR PLASTER BASE COATS

Lime for use as base coats may be either quicklime or hydrated lime made into a lime putty. If the former is used it must be slaked and aged as described on page 18. A small quantity of hair is mixed with the putty as a reinforcing material. The customary amount used is one-half pound of hair to 100 pounds of lime.

Either high calcium lime or dolomitic lime may be used for plaster base coats. Hydrated lime manufactured from the dolomite deposits of Northwestern Ohio has exceptionally high plasticity and easy working qualities.

Lime putty is mixed with sand for scratch and brown coats in the proportion of one part lime putty to two parts of sand by volume. Sand used should meet the following A.S.T.M. specifications, C-35-30:

> "Sand for lime plaster shall consist of hard, strong, durable, uncoated, mineral or rock particles, free from injurious amounts of saline, alkaline, organic or other deleterious substances.
>
> "Sand for lime plaster shall be uniformly graded from fine to coarse within the following limits:
>
> "Retained on a No. 4 (4760-micron) sieve – none
> Retained on a No. 8 (2380-micron) sieve – not more than 10 per cent
> Retained on a No. 30 (590-micron) sieve – {not more than 80 per cent, not less than 15 per cent}
> Retained on a No. 50 (297-micron) sieve – {not more than 95 per cent, not less than 20 per cent}
> Retained on a No. 100 (149-micron) sieve – not less than 95 per cent
> Weight removed by decantation – not more than 5 per cent"

The scratch coat must be applied over a base having a mechanical key. It must be thoroughly and deeply scratched to receive the brown coat and must be

Lime for Finishing Plaster

allowed to dry thoroughly before applying the brown coat.

The brown coat must not be applied to a thickness beyond which the suction of the scratch coat will not tighten up or pack down the brown coat. The brown coat must be thoroughly roughened and allowed to dry and harden before applying the finishing coat.

As lime base coats require thorough drying, artificial heat and complete ventilation are a necessity during the winter months.

LIME FOR FINISHING PLASTER

The finishing coat on plastered surfaces requires a greater amount of working on the wall in the nature of troweling or floating than do the preceding coats. This is necessary to produce a uniformly finished surface and requires an easy-working material of high plasticity. Lime is extensively used for finishing plaster because it provides these qualities.

Lime is seldom used for the finish coat without the addition of some gauging material. If used alone it must be troweled at frequent intervals until it hardens to prevent shrinkage cracks. Lime does not set but hardens very slowly by taking carbon dioxide out of the air.

The gauging materials used with lime to counteract this tendency to shrink and crack and to make the finish set are: plaster of Paris or gypsum gauging plaster. When a specially hard smooth surface is desired, Keene's Cement is used as gauging. When a sand float is desired, sand only is added to the lime putty.

Finishing Quicklimes

Quicklimes maybe used for finishing purposes if the rock from which they are produced is of sufficient purity to make a pure white lime when burned. Any of the sizes of quicklime may be used but the lime must be slaked to a putty following the procedure outlined on page 18. The finer sizes are preferable because with these there is less possibility of unslaked particles remaining in the putty which would result in "pitting" or "popping" in the finished plaster coat.

Putty made from quicklime requires aging for several days after slaking. On large construction jobs a considerable space must be occupied for slaking and storing the lime putty. Additional labor is necessary for carrying the putty from storage to the rooms in which the finishing is being done.

Hydrated Finishing Limes

The use of hydrated limes for finishing plaster avoids the delays encountered from the use of quicklime. Hydrated lime does not require slaking on the job and can be prepared to a putty a few hours before it is required for mixing. It requires no aging and can be prepared in small quantities at a location convenient to the work. (See page 19 for directions for preparing hydrated lime putty.)

Because it is finely ground and air separated there are few impurities in hydrated finishing lime. Scientific hydration at the mill eliminates the presence of any unslaked particles and the consequent possibility of "pitting" or "popping" on the wall.

The best type of hydrated finishing lime is produced from dolomite. Because the dolomite deposits in Northwestern Ohio are acknowledged to be the best for this purpose, this district produces over 50% of the dolomitic hydrated lime used in the United States and 95% of the finishing lime. These dolomitic limes are of uniform whiteness, free from impurities, are cool working and have excellent plasticity and covering capacity. The U S G plant at Genoa, Ohio, is the largest in that field and is equipped with both rotary and shaft kilns.

Applying Lime Finish Coat

LIME • IN BUILDING CONSTRUCTION

Mixing and Applying Lime Putty Finish

GAUGING PLASTERS

For use with lime putty in preparing finishing plaster, gypsum gauging plasters manufactured from carefully selected gypsum rock assure the best results. These plasters are specially processed and ground to just the right fineness to insure rapid mixing with the lime putty and to work easily. For these reasons gauging plasters are preferable to plaster of Paris.

In some instances local practice has been to sift gypsum wall plasters for use as a gauging. This does not produce satisfactory results because wall plasters are not ground to the correct fineness for easy mixing and working with lime putty.

USG gauging plaster is obtainable in gray or white and with quick setting or slow setting quality. The quick set is preferable where the area to be finished is small and frequent changing of scaffolds is necessary. Slow set is adapted for use where large areas can be laid on and worked from one setting of scaffolds.

For a complete description of gauging plaster see USG Red Book and Plasterer's Time Book.

Keene's Cement

When plastered surfaces of extreme hardness are desired or are to receive fine decorative treatment, USG *Keene's Cement is used with lime putty to make the finishing plaster coat.

USG Keene's Cement is the hardest and densest gypsum material applied with a trowel. It is manufactured from specially selected gypsum rock. It has superior smooth, uniform working qualities and high tensile strength.

MIXING AND APPLYING LIME PUTTY FINISH

The lime putty which has been prepared from quicklime or hydrated lime as described in preceding paragraphs is used to make a shallow ring on the gauging board. (See illustration below.) Water is then placed in this ring and the gauging plaster or Keene's Cement sifted into the water and permitted to soak until it is thoroughly wetted. The soaked gauging material and the lime putty are then thoroughly mixed together.

The proportions of materials used in lime putty finish are:

1 part dry gauging plaster by measure to 3 parts lime putty by measure. This equals 1 part dry gauging plaster by weight and 2 parts dry hydrated lime by weight.

80 pounds lime putty to 100 pounds Keene's Cement (for medium hard finish).

25 pounds lime putty to 100 pounds Keene's Cement (for hard finish).

A lime putty and gauging plaster finish is applied over properly roughened dry walls in two coats. The first coat is applied thin and well troweled into

Applying Keene's Cement and Lime Finish

Making Lime Putty Ring on Mixing Board

*Reg. Trade Mark.

Lime in Stucco Basecoats

the base. The first coat should be allowed to draw 5 to 10 minutes before applying the second coat. The second fills in imperfections and is troweled to a smooth finish before the finishing coat has set.

Lime and Keene's Cement finish is applied in two coats after the suction of the base coat has been reduced by uniform dampening. The first coat is laid on and allowed to draw down. The second coat is then applied and troweled smoothly and evenly. If a highly polished surface is desired, the finish is dry troweled occasionally until it is set. For a tile effect, the surface is marked off into units of uniform size while the finish is still "green".

The covering capacity of lime putty finish depends upon the mechanic, conditions of application and trueness of base coat. One ton of hydrated lime will cover from 500 to 700 square yards. One ton of quicklime should finish about 1000 square yards.

SAND FLOAT FINISH

Sand float finishes are produced by mixing three parts sand to one part lime putty by weight with sufficient water to give the proper consistency.

Sand float finish is applied in two coats over dry base coat. The first coat is well troweled into the base. The second coat fills in imperfections and is finished with a cork, carpet or felt float to a true and even surface free from float marks and cat faces. The floating must be entirely finished before the finish coat has set.

LIME IN STUCCO BASECOATS

Stucco has been used as an exterior finish of buildings for centuries. The plastic material used in Europe was lime or hydraulic cements or combinations of these materials. In America, stucco exteriors came into use with the development of Portland cement and American stuccos are usually mixtures of Portland cement, lime and sand.

The requirements for a good stucco are tensile strength, durability and water-tightness. The advantages of using lime in stucco are: increased workability, greater plasticity, higher water-tightness and increased extensibility.

Lime adds these advantages to stucco for the same reasons outlined under Masonry Mortar. Lime makes stucco watertight by increasing the workability of the mix and filling the pores or voids between the grains of sand thus preventing the passage of water through the stucco.

Lime putty made from quicklime may be used in mixing stucco base coats but hydrated lime saves time and has more uniform working qualities. Hydrated lime for stucco can be mixed dry with the cement and sand. It is easily handled and is obtainable wherever Portland cement can be had.

The Universal-Atlas Portland Cement Company in "Houses of Stucco" recommend the use of the following mixture for both base coats and finish coat: "1 volume of cement to 3 volumes of aggre-

This attractive ornamental plastering in the Field Museum, Chicago was made with U S G Ivory Keene's Cement.

gate. Hydrated Lime in a content of approximately 10 pounds per bag of cement."

These ingredients are thoroughly dry mixed and a sufficient amount of water added to make a mortar of proper working consistency.

U S G produces a factory mixed basecoat for stucco which contains the proper proportions of lime, sand and Portland cement to provide a strong, durable base for the stucco finish. This is recommended in preference to job mixed base coats.

LIME IN STUCCO FINISHES

While the mixture recommended above is excellent for basecoat work, it is not sufficiently plastic for the wide variety of textures commonly used in the finish coats of stucco.

The finish coat for exterior stucco may consist of eighty per cent by weight of a well graded fine to coarse sand with twenty per cent of cementing agent. The cementing agent may be varied from fifty to ninety per cent of Portland Cement, and the remainder (10% to 50%) hydrated finishing lime. Only hydrated lime of the best finishing quality should be used.

Obviously if color finishes are required, white Portland Cement should be used and light colored sand (silica or ground marble) together with mineral lime-proof pigments. The brand of colors selected should be manufactured by a responsible concern and the manufacturer's directions followed very strictly in proportioning and mixing.

U S G Oriental *Stucco finishes are factory mixed and contain the proper proportions of lime, sand, Portland cement and mineral pigments to provide an easily textured finish of lasting color.

LIME IN CONCRETE

Hydrated lime is used as an admixture in concrete for its qualities of water-tightening, lubricating and physical stabilization.

Water-tight concrete is concrete through which water cannot pass as contrasted with a water-proof concrete which is only surface treated to prevent the entrance of water. Water-tight concrete has all the advantages of water-proof concrete but has additional qualities that make for better concrete construction.

*Reg. Trade Mark.

Stucco provides an attractive exterior.

Lime makes concrete flow more easily. Illustration, courtesy Portland Cement Association.

Advantages of Lime in Concrete

The first requirement for a water-tight concrete is the proper proportioning of the aggregates to provide a dense concrete.

Hydrated lime makes concrete water-tight for these reasons: It increases workability; reduces honeycombing, stone pockets, etc.; fills voids; prevents segregation; reduces the relative amount of water required.

Workability

Because of its high plasticity hydrated lime has been used for years in improving the working quality of mortar, plaster and stucco. It mixes easily with water and lubricates the other materials with which it is used. This lubricating quality makes concrete flow more easily from chutes, wheelbarrows or buggies. It makes the concrete fill the forms and lie close to the reinforcing steel with less spading.

Honeycombing and Stone Pockets

The lubricating quality of hydrated lime causes the particles of aggregate to arrange themselves closely together into a dense mass. This eliminates pockets and honeycombing and produces a smooth surface when the forms are removed, doing away with pointing and patching.

Filling Voids

The fineness of hydrated lime coupled with its lubricating quality permits it to enter and fill the small pores or voids between the smaller pieces of aggregate thus effectively preventing the passage of water through the concrete.

Segregation

In an effort to make the concrete mass easy to handle, it is common practice to use an excess of water in mixing. This causes the grout to run away from the aggregate and leave pockets or causes the ingredients to separate into strata or layers. Hydrated lime in the concrete will provide proper lubrication to the mix. This assures easy handling and prevents segregation and consequent weakening of the concrete.

Reduction of Mixing Water

As pointed out in preceding paragraphs the addition of hydrated lime to the concrete mix lubricates the mass without using an excess of water. The water used to convert the hydrated lime into a paste is held and does not evaporate quickly. When the Portland cement has used up the free water in the mixture it draws on the moisture held by the hydrated lime. This insures a more complete hydration of the cement assuring greater strength to the concrete, without using an excess of water in the mix.

Volume Changes in Concrete

It is generally recognized that volume changes in concrete are the result of alternate wetting and drying of the concrete. The stresses set up by expansion and contraction due to these changes in moisture content are more intense than those caused by temperature changes. Obviously, preventing the entrance of water by making the concrete water-tight will prevent these volume changes. The correct proportioning of aggregate with the addition of hydrated lime will produce a dense impervious concrete.

Proportion of Lime To Use

Lime used in concrete should be hydrated and is added to the batch of materials before feeding to the mixer. The quantity of hydrated lime depends on the nature and size of the aggregates used. Clean, coarse sand of uniform size will require a larger quantity than fine well graded sand. Large aggregate of crushed stone will require more than well graded gravel.

The following are the percentages of hydrated lime for various mixes as recommended by the National Lime Association, Bulletin No. 301A:

"1:1½:3 concrete – 7 pounds of hydrated lime for each sack of cement or 7 per cent of the cement.

Hydrated lime increases plasticity of concrete.

1:2:4 concrete – 10 pounds of hydrated lime for each sack of cement or 10 per cent of the cement.

1:2½:5 concrete – 12 pounds of hydrated lime for each sack of cement or 12 per cent of the cement.

1:3:6 concrete – 15 pounds of hydrated lime for each sack of cement or 15 per cent of the cement.

"Hydrated lime weighs approximately 40 pounds per cubic foot and an eight-quart pail will contain approximately 10 pounds."

LIME FOR WHITEWASH

Lime prepared in the form of whitewash provides an economical durable covering for all exterior surfaces, where it is not practical to use oil paint or where a frequent renewal of surface covering is necessary. Whitewash provides:

1. Weather protection of all exposed surfaces.
2. Rust protection for iron surfaces.
3. Increased fire resistance of wood.
4. Sanitation in dairy, barn and milk houses.
5. Bright clean interiors.
6. Better appearance of buildings.

Formula for Old-Fashioned Whitewash

Dissolve 2 lbs. of common table salt in a 10-qt. pail filled ¾ full with water. Add contents of a 10-lb. package of hydrated lime. Stir with a wooden paddle until free from lumps and about the consistency of cream. Cover and allow to stand 12 to 60 hours, stirring occasionally. Before using, thin with water to a workable consistency and stir thoroughly. Apply with a brush or spray pump. This quantity will cover about 900 sq. ft. of wood surface.

Formula for More Durable Whitewash

For a weatherproof exterior, which will not rub or chalk, and may be used inside or outside, the following (from "Lime in Agriculture", published by the National Lime Association) is an excellent formula:

"Soak five pounds of casein in about two gallons of water (preferably hot) until thoroughly softened – (about two hours). Dissolve three pounds of trisodium phosphate in about one gallon of water and add this solution to the casein. Allow this mixture to dissolve. Prepare a thick cream by mixing fifty pounds of hydrated lime in about seven gallons of water, stirring vigorously. Dilute three pints of formaldehyde with about three gallons of water. When the lime paste and the casein solution are both thoroughly cool, slowly add the casein to the lime, stirring constantly. Just before using, slowly add the formaldehyde solution to the batch, stirring constantly and vigorously. Care must be taken not to add the formaldehyde solution too rapidly, as that may cause the casein to jell, thus spoiling the batch. CAUTION: Do not make up more of this formula than can be used in one day."

Approximate Covering Capacity of Whitewash

Whitewash weighs about twelve pounds per gallon. The covering capacity per gallon is as follows:

On wood surfaces, about 225 square feet.
On brick surfaces, about 180 square feet.
On plaster surfaces, about 270 square feet.

Whitewash Hints

A pint of molasses added to 5 gallons of whitewash will cause it to penetrate into wood surfaces.

An ounce of alum added to a gallon of whitewash will prevent it from rubbing off.

Silicate of soda, in the proportion of 1 part soda to 10 parts whitewash, will make whitewash more fire resistive.

To obtain a gloss, add a pound of ordinary bar soap dissolved in a gallon of boiling water to approximately 5 gallons of thick whitewash.

Whitewash containing organic matter—milk, glue, flour, etc.—should not be used in damp places.

A good whitewash for poultry houses is made by using boiling water in preparing the whitewash and adding for each 5 gallons of whitewash ¼ pint of hot melted lard or grease, stirring thoroughly. Add 4 ozs. of carbolic acid, creosote, or other coal tar disinfectant before using.

LIME • IN BUILDING CONSTRUCTION

U S G Service—Containers for Building Limes

A NATIONAL LIME SERVICE

The United States Gypsum Company has for many years provided a national manufacturing and distributing service to the building industry in gypsum plaster, wallboard and other essential building products. Now this service includes Lime.

Location of U S G Lime Plants

The lime producing plants of U S G are located at strategic points where the purest deposits of limestone are to be found from New England in the East to Washington in the West and Texas in the South. This adds the national distribution of lime to that of other U S G products. (See pages 16-17.)

Diversity of Lime Products

This wide distribution of plant locations includes excellent quality limestone deposits of both high calcium and dolomitic rock making possible the production of building limes of a composition to meet all requirements that have become established by local customs.

Modern Equipment

The manufacture of a high quality lime, like any other building material requires modern equipment operated by thoroughly experienced workmen under capable management. All U S G lime plants contain the latest equipment available in crushing, grinding and air-separating machinery as well as modern shaft and rotary kilns.

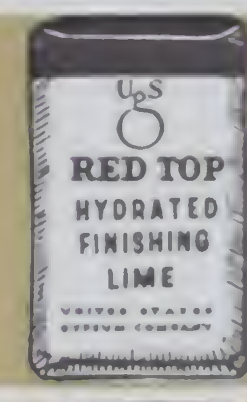
Laboratory Control

As limestone deposits vary in their chemical composition, a chemical laboratory for control of production is an essential in the manufacture of lime for building uses to assure continuous uniformity in working qualities. Every operation in U S G lime plants is under rigid laboratory control.

Nationally Recognized

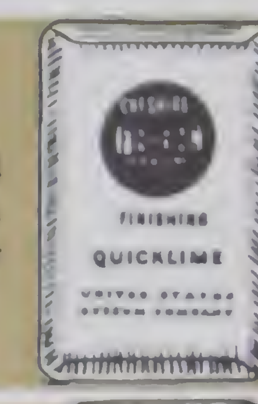
These are the reasons that have established U S G building limes as national leaders in uniformity of composition: availability in all markets; excellent keeping qualities; easy working qualities; and the production of rich fat mortars and plasters.

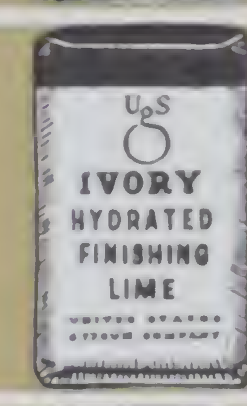
UNITED STATES GYPSUM COMPANY MASONS AND FINISHING LIMES



Red Top Hydrated Finishing Lime
Dolomitic, produced at Genoa, Ohio. High Calcium, produced at Farnams, Mass. Shipped in 50 lb. paper valve bags.

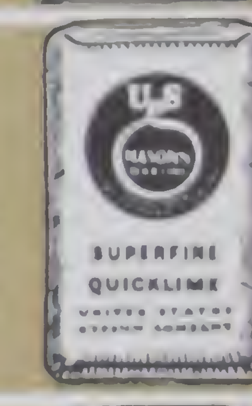
Cheshire Finishing Quicklime
High Calcium, produced at Farnams, Mass. Shipped in 80 lb. paper bags.

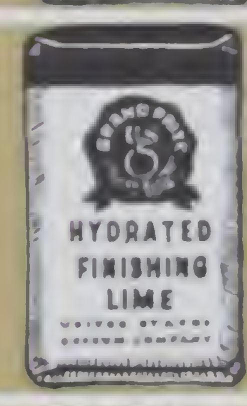




Ivory Hydrated Finishing Lime
Dolomitic, produced at Genoa, Ohio. Shipped in 50 lb. paper valve bags.

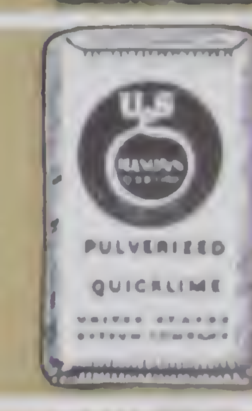
U S G Superfine Mason's Quicklime
High Calcium, produced at Farnams, Mass. Shipped in 80 lb. paper bags.

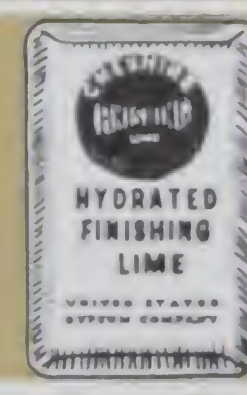




Grand Prize Hydrated Finishing Lime
Dolomitic, produced at Genoa, Ohio. Shipped in 50 lb. paper valve bags.

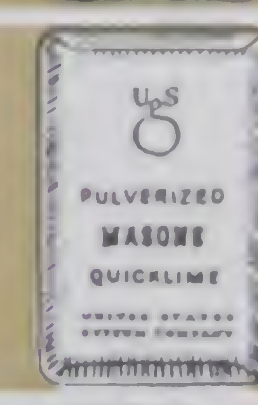
U S G Pulverized Mason's Quicklime
High Calcium, produced at Farnams, Mass. Shipped in 80 lb. bags.

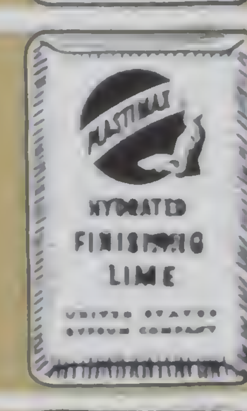




Cheshire Hydrated Finishing Lime
High Calcium, produced at Farnams, Mass. Shipped in 50 lb. paper valve bags.

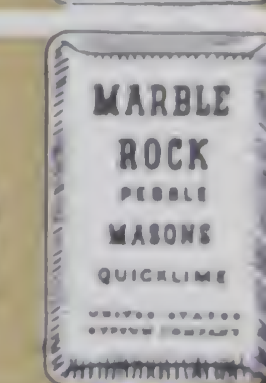
U S G Fine Grain Mason's Quicklime
Dolomitic, produced at Genoa, Ohio. Shipped in 50 lb. bags.

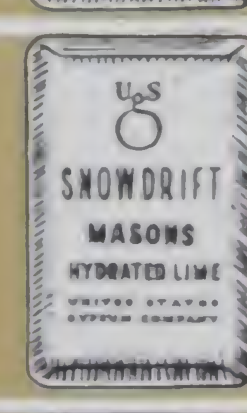




Plastimax Hydrated Finishing Lime
High Calcium, produced at New Braunfels, Texas. Shipped in 40 lb. paper valve bags.

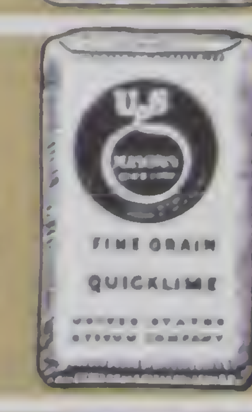
Marble Rock Pebble Mason's Quicklime
High Calcium, produced at Evans, Wash. Shipped in 90 lb. calsax or paper bags.

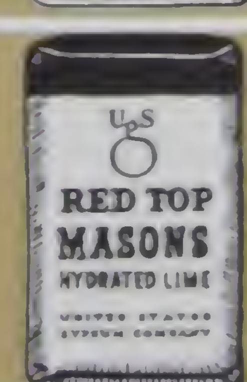




Snowdrift Mason's Hydrated Lime
High Calcium, produced at New Braunfels, Texas. Shipped in 40 lb. paper valve bags.

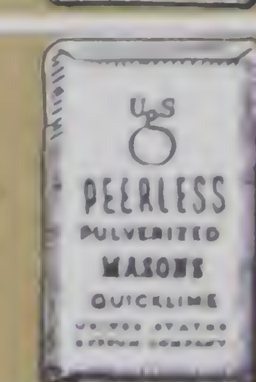
U S G Fine Grain Mason's Quicklime
High Calcium, produced at Farnams, Mass. Shipped in 80 lb. paper bags.

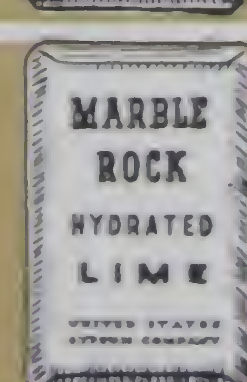




Red Top Mason's Hydrated Lime
Dolomitic, produced at Oakfield, N. Y., Genoa, Ohio, and Cordova, Ill. High Calcium, produced at Farnams, Mass., and Evans, Wash. Shipped in 50 lb. paper valve bags.

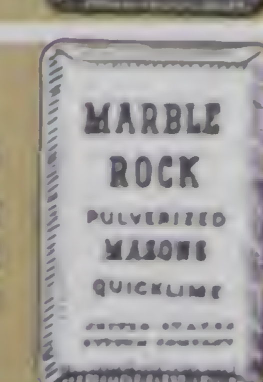
Peerless Pulverized Mason's Quicklime
High Calcium, produced at New Braunfels, Texas. Shipped in 100 lb. paper bags.





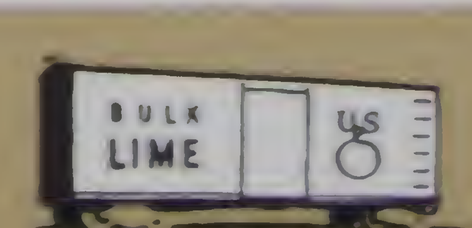
Marble Rock Hydrated Lime
High Calcium, produced at Evans, Wash. Shipped in 50 lb. and 100 lb. bags.

Marble Rock Pulverized Mason's Quicklime
High Calcium, produced at Evans, Wash. Shipped in 60 lb. and 90 lb. paper bags.



All brands of U S G Quicklimes can be shipped in wood barrels or steel drums from all mills excepting Cordova, Illinois, which ships in steel drums only.

All U S G brands of Quicklime can be shipped in bulk.



U S G Lump Lime can be shipped in bulk from all mills.

LIME
FOR SOIL CORRECTION AND CROP PROTECTION

■ Lime for correcting soils and improving crop returns has been used for centuries. The same conditions that have created lime-poor soils are still operating and will continue to operate. Soil liming is always an important consideration in the world's basic industry — agriculture.

Where Lime is Needed

All soils that are "sour" or "acid" are lacking in lime. Lime must be added if such soils are to produce crop yields that will make it profitable to work them.

Acid soils are found in every section of the United States. When the country was new most of the virgin soil was amply supplied with lime but constant cropping without replacing the lime has made them lime-poor and turned them into acid soils.

Some of the virgin soils were acid from the first time they were put under cultivation and have always been classed as poor land. Soils of this nature are found in every state. These acid areas are growing larger and new areas are developing every year where liming is not being done.

Why Soils are Acid

Soils are acid because they do not contain lime in the right proportion. These soils may have always lacked lime or may have become depleted by leaching and cropping or may become sour from processes which add acid to the soil.

1—LEACHING The greater the rainfall, the more alkaline materials are carried out of the soil by the leaching action of the water. Lime usually leaches away faster than other elements. At the Cornell Experiment Station it was found that the following elements were carried away during a year from one acre of soil, not limed or fertilized.

Calcium	177.1 lbs.
Sodium	83.5 lbs.
Potassium	46.3 lbs.
Magnesium	33.8 lbs.

On this basis, drainage water would remove from one acre in six years, a volume of lime equal to one ton of agricultural hydrated lime.

2—CROPPING Plants require lime as plant food. Some plants particularly clover and other legumes commonly used in crop rotation, require more than others. Every crop removes lime from the soil. An average crop of alfalfa will take away about 100 pounds of lime per acre; clover and cow peas 55 pounds and soy beans 35 pounds.

3—ACID ELEMENTS ADDED Rain often carries into the soil acid forming elements such as sulphur. Decaying organic matter in the soil, such as green or stable manure, stubble, etc., produces acids. Certain chemical fertilizers containing sulphur, ammonium sulphate or ammonium nitrate leave acid residues in the soil.

What Lime Does to the Soil

The addition of lime to soil makes it more productive for several reasons:

1. It changes acid soils by neutralizing the acids. Practically all farm crops grow better in neutral or only slightly acid soils.

2. It supplies calcium to replace this all important plant food that is being constantly removed from the soil by the leaching action of drainage and consumption by growing crops.

LIME • FOR SOIL CORRECTION AND CROP PROTECTION

The Kind of Lime to Use—When to Apply

3. It makes the soil more loose and porous so that air circulation and drainage are improved. This loosening effect on heavy soils makes plowing and cultivating easier and assures a seed bed through which plant roots can easily grow.

4. It speeds up the decaying or decomposing action of green or stable manures and other organic matter. The production of nitrogen compounds available for plant food from organic matter is the work of minute bacteria which function most effectively in soils well supplied with lime.

5. It increases the value of fertilizers which will not produce maximum results in acid soils. Lime by neutralizing the acids in the soil and loosening the soil assures more effectiveness from the fertilizer.

The Kind of Lime to Use

Lime for agricultural use is obtainable in two forms, Ground Limestone and Agricultural Hydrated Lime.

Ground Limestone is untreated rock as it comes from the quarry, ground to a fineness that makes its lime content available when applied to the soil.

Agricultural Hydrated Lime is limestone that has been burned, ground, and thoroughly slaked and reground to a fine powder.

If immediate results are wanted, hydrated lime is best because its fine particles act at once on the soil. The next choice would be a limestone finely ground to make its lime content available.

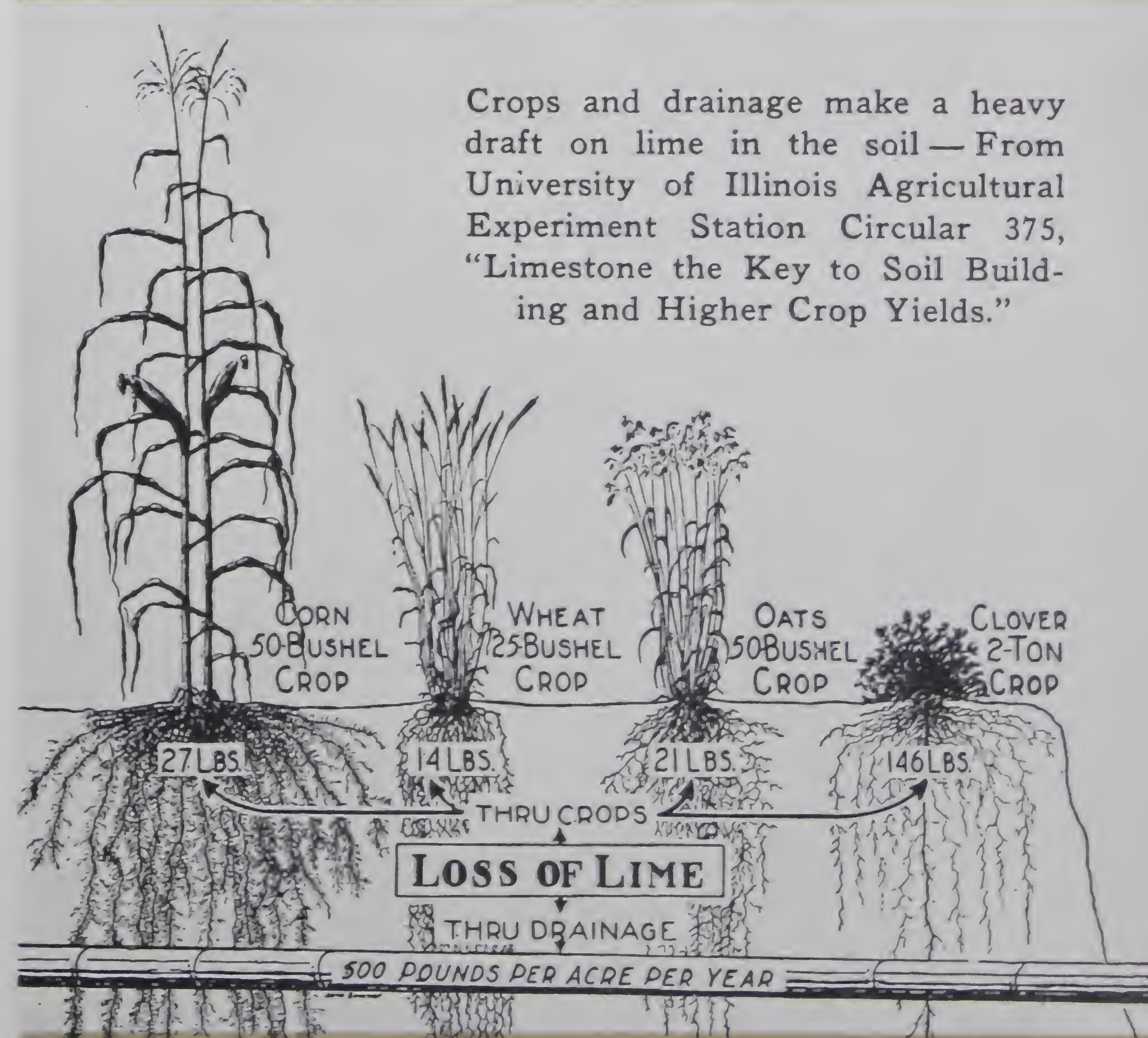
If the soil to be limed is heavy with a tendency to become lumpy or to bake, the loosening action of hydrated lime would indicate its use.

When to Apply Lime

To get the best results lime or ground limestone should be applied immediately after plowing so that discing and harrowing will thoroughly work it into the soil. If the crop is to be put in with a drill, hydrated lime or fine limestone can be applied when the drilling is done.

There is a difference of opinion among authorities as to whether a complete application should be made at one time during the crop rotation, or two or more smaller applications. Partial applications may be of value to the immediately succeeding crop, but may not fully remedy the acid condition.

The unlimed strip in this field convinced the owner that liming meant the difference between a good crop of carrots and failure.



Crops and drainage make a heavy draft on lime in the soil — From University of Illinois Agricultural Experiment Station Circular 375, "Limestone the Key to Soil Building and Higher Crop Yields."

LIME • FOR SOIL CORRECTION AND CROP PROTECTION

How to Apply Lime—Lime for Insecticide Carrier

With limited finances available, the partial application may be preferable.

If circumstances prevent the application of lime immediately after plowing, it may be applied at a later date or even during the winter.

How to Apply Lime

Lime may be applied by spreading with a shovel from piles or from a wagon. It is difficult to get a uniform distribution in this manner and it is a disagreeable, hard job, the only harder method being to broadcast the lime by hand. If an appreciable amount of acreage is to be limed, it will be more economical to secure a lime spreader. Frequently several farmers join together and secure a spreader for their common use. A manure spreader can be used to distribute limestone but the application is not so uniform.

Lime for Lawns and Gardens

Nearly all cultivated land in the eastern and midwestern section of the country is sour, or acid, according to the United States Department of Agriculture. This is even more true of gardens and lawns in and around towns where soot, smoke fumes and other acid elements are continually being carried into the ground by snows, rains, and the use of hose in summer. Such a condition prevents a healthy, vigorous and productive soil, as is required for good garden crops and attractive lawns. At the same time, it encourages the growth of weeds and other destructive plants. To effectively counteract this sourness and insure a highly fertile soil, sweeten your lawn with lime. In addition, lime promotes the rapid, steady plant growth so essential to garden vegetables and lawns. It loosens and opens up the soil, provides the proper air circulation and moisture capacity, and releases the valuable plant foods in the soil, so that the plant roots can absorb them.

After the lawn has been established it will require proper feeding with fertilizer and control of acidity by lime applications every three to five years.

Radishes, beets, onions, lettuce, spinach, cauliflower, and brussels sprouts make the best growth when the soil is limed, and the last three varieties are protected from certain diseases.

Other Uses of Lime on the Farm

1. A carrier for insecticides for crop protection.
2. A protection against burning when strong solutions are used in spraying.
3. An aid in decomposing composts.
4. An admixture in concrete and stucco.
5. In making masonry mortar.
6. For treating seeds.
7. For softening water.
8. For sanitation.
9. For whitewash.

For a detailed discussion of the uses of lime in agriculture send for a copy of "Lime on the Farm", published by the United States Gypsum Company.

The fine subdivision of hydrated lime makes it an effective carrier for insecticidal dusts.

Farm buildings can be kept clean and attractive by the frequent application of whitewash.

LIME • GENERAL INFORMATION AND REFERENCES

Specifications — Bibliography

LIME SPECIFICATIONS

These specifications, prepared under the auspices of the National Bureau of Standards, are recommended by the Interdepartmental Conference on Chemical Lime.

NUMBER		PRICE
C 150	Recommended specification for quicklime and hydrated lime for use in the manufacture of sand-lime brick. December 28, 1923	$0.05
C 153	Recommended specification for quicklime and hydrated lime for use in the manufacture of silica brick. December 27, 1923	.05

(Above specifications taken from index dated July 1, 1935)

FEDERAL SPECIFICATIONS

SS-Q-351—Federal specification for quicklime; Type M (Magnesium); Type C (Calcium) (for) structural purposes. August 19, 1930 .05

(All U S G quicklimes produced at the Genoa, Ohio, plant will meet Type M specifications.)

(All U S G quicklimes produced at the Farnams, New Braunfels and Evans plants will meet Type C specifications.)

SS-L-351 Federal specification for lime. Type M (masons); Type F (finishing) hydrated (for) structural purposes, October 14, 1930 .... .05

(All U S G masons hydrate produced at all plants will meet Type M specifications.)

(All U S G hydrated finishing limes produced at the Farnams, Genoa and New Braunfels plants will meet Type F specifications.)

(Above specifications taken from index dated November 1, 1935.)

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U. S. Department of the Interior, I. C. 6884, "Lime", 1936.

Universal Atlas Cement Company — "Houses of Stucco".

National Lime Association Publications:
- Bulletin No. 320 — "Lime Mortar — its relation to watertight masonry".
- Bulletin No. 321 — "Masonry Mortar".
- Bulletin No. 304-C — "White Wash and Cold Water Paints".

Common Brick Manufacturers Association of America — "Brick Structures".

OTHER USG PRODUCTS

Gypsum Base Coat Plasters

Red Top Cement Plaster
Red Top Wood Fibre Plaster
Red Top Sanded Plaster
Eldorado (dark) Plaster
Bondcrete for Interior Concrete Surfaces

Gypsum Finishing Plasters

Red Top Trowel Finish
Red Top Universal Trowel Finish
Red Top Adamant Trowel Finish
Red Top Badger Trowel Finish
Red Top Sand Float Finish
Red Top Silica Sand Float Finish
Red Top Adamant Sand Float Finish

Colored Finishing Plaster

Oriental Interior Finish

Gypsum Gauging Plasters

Red Top Slow Set Gauging Plaster
Red Top Star Gauging Plaster
Red Top Superfine Finishing Plaster
Red Top Quick Set Gauging Plaster
Red Top Champion Gauging Plaster
Red Top King's Diamond Gauging Plaster
Red Top N Y C Mills Gauging Plaster

Prepared Stucco

Oriental Stucco Base Coat
Oriental Stucco Finishes (in colors)

Plastering Bases

Rocklath Gypsum Board Lath
Perforated Rocklath
Insulating Rocklath
Weatherwood Insulating Lath
Weatherwood Reinforced Insulated Lath
Red Top Diamond Mesh Lath
Red Top Z-Rib Metal Lath
Red Top 3/8-inch Rib Metal Lath
Red Top Expanded Stucco Mesh

Plastering Accessories

Red Top Cornerite
Red Top Corner Beads
Red Top Metal Arches
Red Top Channels
Base Screeds and Picture Mould
Tie Wire, Nails and Staples

Plastering Systems

Rocklath Resilient Plastering System
Red Top Metal Lath Resilient Plastering System
Standard-X Plastering System

Gypsum Wallboards

Sheetrock, The Fireproof Wallboard
Wood Grained Sheetrock
Sheetrock Panelwood
Quarter-inch Sheetrock
Insulating Sheetrock
Sheetrock Tileboard
One-half inch Sheetrock
Recessed Edge Sheetrock
Tongue and Groove Sheetrock
Adamant Liner Board

Joint Finishing Systems for Wallboard

Sheetrock Finisher
Sheetrock "Metal A" system
Sheetrock "Perf-a-tape" system
Sheetrock Finisher

U S G Resilient Sheetrock System

Gypsum Sheathing

Gyplap, The Fireproof Sheathing

Fibre Wallboards

Red Top Fibre Wallboard
Tiger Fibre Wallboard

Structural Insulating Boards

Weatherwood Insulating Board
Weatherwood Insulating Plank
Weatherwood Insulating Tile
Weatherwood Insulating Sheathing
Weatherwood Insulating Roof Sheathing

Fill and Blanket Type Insulation

Red Top Junior Bat Insulating Wool
Red Top Bat Insulating Wool
Red Top Strip Insulating Wool
Red Top Nodulated Insulating Wool

Red Top Expanded Metal

Red Top Concrete Reinforcement
Red Top Machine Guards, Partitions, Etc.
Shelf-X Expanded Metal

U S G Roofing Products

U S G Asphalt Shingles
U S G Asphalt Roll Roofings
U S G Saturated Sheathings
U S G Building Papers
U S G Asbestos Mineral Surface Roll Roofings
U S G Asbestos Felts and Base Sheets
U S G Built-Up Asphalt Roofings
U S G Saturated Felts
U S G Asphalt Paints, Plastic Cements and Coatings
U S G Roofing Pitch and Refined Coal Tar
U S G Roofing Asphalt

U S G Asbestos Insulation Materials

U S G Pipe Coverings
U S G Sheet and Block Insulation
U S G Asbestos Cement

U S G Paint Products

Texolite Casein Wall Paint
Texolite Deep Colors
Texolite Art Colors
K-Cemo Primer
Duracal Washable Calcimine
Kal (hot-water) Calcimine
U S G Calcimine
Cementico Cement Paint
Textone, the Plastic Paint
U S G Texture Paint
Textone Sealer
Textone Glaze
Red Top Patching Plaster
Red Top Painters Plaster
U S G Cold Water Putty
U S G Lime Proof Colors

U S G Gypsum Construction (Engineering Sales Division)

Sheetrock Pyrofill Roofs
Weatherwood Pyrofill Roofs
Pyrofill Roof Construction
Pyrobar Roof Tile
Pyrobar Partition Tile
Pyrobar Column, Beam and Girder Tile
Pyrobar Precast Floor & Roof Tile
Pyrobar Precast Ceiling Tile
Metal Bound Gypsum Floor and Roof Tile
Red Top Rib Floors
U S G Steel Roof Decks

U S G Sound Control Service (Engineering Sales Division)

Acoustone Tile
Quietile (Low density wood Fibre)
Perfatile (Metal Pan Type)
Sabinite Acoustical Plaster
U S G System of Sound Insulation

U S G Industrial Products

Pottery Plaster
Dental Plaster
Casting Plaster
Moulding Plaster
Metal Casting Plaster
Terra Alba Filler
Calcium Sulphate Filler
Hydrocal Industrial Casting
Hydrostone
Land Plaster
Ground Gypsum
Insecticide Carriers
Whiting

For detailed information on U S G Building Products write for "U S G Red Book" (RB-1) and "Lathing and Plastering Materials" (X-170). Details of U S G Sound Control Service, Gypsum Constructions and Industrial products sent on request.